Project Report: The impact of atmospheric particles on life

Project Investigator:	***Owen Toon***

Project Progress

During the past year the group made progress in a number of areas. Melissa Trainer, a student in Maggie Tolbert's group, completed two sets of experimental studies related to the formation of aerosols in the early atmosphere of Earth and the current atmosphere of Titan. As had been predicted in some theoretical studies we found that the production rate of aerosols declines as the abundance of CO_2 relative to methane increases in simulated terrestrial atmospheres. This paper has been submitted to the journal Astrobiology. We also found that PAHs and terpene related compounds can be formed in Titan's atmosphere, with the unexpected result that the type of organic compounds formed shifts for CH_4 to N_2 ratios close to those in Titan's current atmosphere. This work has been submitted to the special issue of GRL on predictions for Cassini. Jen Heldmann graduated from the University of Colorado and moved to NASA Ames. She recently published a paper in Icarus related to gulley formation on Mars. Her work shows that the gullies are likely related to underground liquid water reservoirs and probably were formed under current Martian climate conditions. They represent the most likely place to find life on Mars in our opinion. Tian Feng has completed a study of the escape of H_2 from extrasolar planets and from the early Earth. We have submitted the extrasolar planet work to the Astrophysical Journal. It explains the observed structure of one extrasolar planetary atmosphere, and shows that planets can evaporate in the inner solar system. The terrestrial work points to hydrogen rich atmospheres with hydrogen partial pressures above 1 bar on early Earth. Brian Toon working with a group of paleontologists examined the evidence for survival at the KT boundary. In a paper in Geological Society of American Bulletin they showed that the initial in−fall of debris broiled all unprotected creatures alive within hours. Hence only those sheltered in holes or water survived. Alex Pavlov has submitted a paper to Nature showing that passage of the Earth through an intergalactic dust cloud would have plunged the Earth into a snowball state.

Several students, Melissa Trainer, Dan Curtis, Jen Heldmann, Teresa Segura, Kaj Williams, and Atilla Elteto, continued in the NASA Graduate Student Researchers Program (GSRP), or won new fellowships in that very competitive program. Maggie Tolbert was elected to the National Academy of Sciences.

Highlights

- Melissa Trainer, a student in Maggie Tolbert's group, completed experimental studies showing, as had been predicted in some theoretical studies, that the production rate of aerosols declines as the abundance of CO_2 relative to methane increases in simulated ancient terrestrial atmospheres.
- Melissa Trainer, a student in Maggie Tolbert's group, completed experimental studies showing that PAHs and terpene related compounds can be formed in Titan's atmosphere, with the unexpected result that the type of organic compounds formed shifts for CH_4 to N_2 ratios close to those in Titan's current atmosphere.
- Jen Heldmann showed that the gullies on Mars are likely related to underground liquid water reservoirs and probably were formed under current Martian climate conditions. They represent the most likely place to find life on Mars in our opinion.
- Tian Feng completed a study of the escape of H_2 from extrasolar planets and from the early Earth. The work explains the observed structure of one extrasolar planetary atmosphere, and shows that planets can evaporate in the inner solar system. The terrestrial work points to hydrogen rich atmospheres with hydrogen partial pressures above 1 bar on early Earth.
- Brian Toon working with a group of paleontologists examined the evidence for survival at the KT boundary. They showed that the initial in−fall of debris broiled all unprotected creatures alive within hours. Hence only those sheltered in holes or water survived.
- Alex Pavlov has submitted a paper to Nature showing that passage of the Earth through an intergalactic dust cloud would have plunged the Earth into a snowball state.
- Maggie Tolbert was elected to the National Academy of Sciences.

Roadmap Objectives

- ***Objective No. 1.1:*** Models of formation and evolution of habitable planets
- ***Objective No. 4.1:*** Earth's early biosphere
- ***Objective No. 4.3:*** Effects of extraterrestrial events upon the biosphere